U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

3.5.1.2 INTERNALLY GENERATED MISSILES (INSIDE CONTAINMENT)

REVIEW RESPONSIBILITIES

Primary - ~~Auxiliary~~Plant Systems Branch ~~(ASB)~~(SPLB)[1]

Secondary - None

I. AREAS OF REVIEW

The ~~ASB~~SPLB[2] review of the structures, systems, and components (SSC) to be protected from internally generated missiles (inside containment) to assure conformance with the requirements of General Design Criterion 4 includes all SSC within the containment and the containment itself. The review includes internally generated missiles associated with component overspeed failures, missiles that could originate from high energy fluid system failures, and missiles due to gravitational effects.

The ~~ASB~~SPLB[3] with the requested assistance of the Containment Systems and Severe Accident Branch ~~(CSB)~~(SCSB)[4] and the Reactor Systems Branch ~~(RSB)~~(SRXB)[5] reviews the functional operations and performance requirements for ~~structures, systems, and components~~SSC[6] inside containment and identifies which of the operations are necessary for the safe shutdown of the reactor facility, or prevention of a significant uncontrolled release of reactivity,[7] in the event of an accident or other circumstances that might result in an internally generated missile, or for the mitigation of the effects of loss-of-coolant or other accidents.

~~Safety-related~~ SSC important to safety[8] are reviewed with respect to their capability to perform functions required for attaining and maintaining a safe shutdown condition, or prevention of a significant uncontrolled release of reactivity,[9] during such accident conditions. The review of internally generated missile protection includes the following:

1. Structures, systems or portion of systems, and components requiring protection from internally generated missiles and the methods of protection provided against such missiles.

2. Credible primary missiles including, valve hardware, retaining bolts, relief valves parts, instrument wells and reactor vessel seal rings (PWR).

3. Credible secondary missiles generated as a result of impact with primary missiles.

Review Interfaces:[10]

The SPLB will coordinate with other branches' evaluations and reviews that interface with the overall review of this area as follows: ~~review performed by the Structural Engineering Branch (SEB) is coordinated by the ASB and the results used to complete the overall ASB evaluation of the protection against internally generated missiles.~~[11]

1. The Civil Engineering and Geosciences Branch ~~SEB~~(ECGB)[12] determines the acceptability of the analytical procedures and criteria used for structures or barriers that protect the containment structure and liner, essential systems, and safety-related components from internally generated missiles as part of its primary review responsibility for SRP Section 3.5.3. The results of the review will be used to complete the overall SPLB evaluation of the protection against internally generated missiles.[13]

2. The Mechanical Engineering Branch (EMEB) performs the review of dynamic effects associated with the postulated rupture of piping inside containment under SRP section 3.6.2. Typically included in SRP 3.6.2 is the review of any high-energy line spatial separation analyses performed by an applicant. The results of this review can be utilized to complete the overall SPLB evaluation of the protection against internally generated missiles.[14]

For those areas of review identified above as part of the review under other SRP sections, ~~T~~the acceptance criteria and their methods of application are contained in the referenced SRP sections.[15]

II. ACCEPTANCE CRITERIA

Acceptability of the design information on protection of ~~structures and essential systems and components~~SSC important to safety[16] from internally generated missiles, as presented in the applicant's safety analysis report (SAR), is based on General Design Criterion 4. An additional basis for determining acceptability is the degree of similarity of the design to that of previously approved plants.

The design of ~~structures, systems, and components~~SSC[17] is acceptable if the integrated design affords missile protection in accordance with General Design Criterion 4, as it relates to ~~structures housing essential systems and to the systems~~SSC important to safety[18] being capable of withstanding the effects of internally generated missiles. A statement in the SAR that ~~essential structures, systems, and components~~SSC important to safety[19] will be afforded

protection by locating the systems or components in individual missile-proof structures, physically separating redundant systems or components of the system, or providing special localized protective shields or barriers, is an acceptable method for meeting this criterion at the construction permit stage ~~for providing protection from internally generated missiles (inside containment)~~.[20]

Technical Rationale:[21]

The technical rationale for application of the above acceptance criterion to internally generated missiles (inside containment) is discussed in the following paragraph.

GDC 4 establishes requirements regarding the ability of SSC important to safety to be protected from dynamic effects, including the effects of internally generated missiles. Equipment inside containment such as pressurized components, high-energy piping and rotating equipment all have a potential for generating credible missiles. The initiation of an internally generated missile is a dynamic effect and the impact of those missiles on SSC important to safety must be evaluated to ensure that the SSC important to safety are adequately protected and will be capable of performing their safety functions. Protecting those SSC that are important to safety from the adverse effects of internally generated missiles prevents failure of those systems required for safe shutdown of the reactor facility and prevents significant uncontrolled release of radioactivity.

III. REVIEW PROCEDURES

The review procedures below are used during the construction permit (CP) review to determine that the design criteria and bases and the preliminary design as set forth in the preliminary safety analysis report meet the acceptance criteria given in subsection II. For the review of operating license (OL) applications, the review procedures and acceptance criteria are used to verify that the initial design criteria and bases have been appropriately implemented in the final design as set forth in the final safety analysis report. The reviewer selects and emphasizes areas within the scope of this SRP section as may be appropriate in a particular case.

The first objective in the review of the ~~structures, systems, and components~~SSC,[22] with regard to protection requirements for internally generated missiles, is to determine whether the equipment is needed to perform a safety function. Some structures and systems are designed as safety related in their entirety, others have portions that are safety related, and others are classified as not needed for safety. In order to determine the safety category of the SSC, the ~~RSB~~SRXB[23] and ~~CSB~~SCSB[24] upon request from the ~~ASB~~SPLB[25], will evaluate the SSC with regard to their function in achieving safe reactor shutdown conditions and preventing significant uncontrolled release of radioactivity[26] or in preventing accidents or mitigating the consequences of accidents, and will provide an input to the ~~ASB~~SPLB[27]. The primary reviewer obtains such input as required to assure that this review ~~procedure~~[28] is complete. ~~Structures, systems, or components~~SSC[29] that perform a safety function, or by virtue of their failure could have an adverse effect on a safety function should be protected from the effects of internally generated missiles.

A review is conducted of the information provided in the SAR pertaining to SSC design bases and criteria, the listing of credible primary missiles, secondary missiles, damage or failures to ~~safety-related SSC~~SSC important to safety[30] as a result of missile impingement and missile protection provided. The reviewer may use failure mode and effect analyses and the results of other portions of the facility review in evaluating specific SSC and the origin of possible missiles, and in determining which ~~structures, systems, and components~~SSC[31] require protection from internally generated missiles and whether the degree of protection provided is adequate. The missile protection provided for SSC important to safety is adequate if the protection is provided by one or more of the following: (1) locating the system or component in a missile-proof structure, (2) separating redundant systems or components for the missile path or range, (3) providing local shields and barriers for systems and components, (4) designing the equipment to withstand the impact of the most damaging missile, (5) providing design features to prevent the generation of missiles, (6) orienting missile sources to prevent missiles from striking equipment important to safety.[32]

The reviewer determines that controls are provided to ensure that unsecured maintenance equipment, including equipment required for maintenance and equipment undergoing maintenance, will be removed from containment prior to operation, moved to a location where it is not a potential hazard to SSC important to safety, or seismically restrained to prevent it from becoming a missile.[33]

The following review procedures are applicable to new applications:

1. The reviewer determines that the statistical significance of an identified missile can be evaluated utilizing a probability analysis. Once a potential missile is identified, its statistical significance is determined by calculating the probability of missile occurrence. If this probability is less than 10^{-7} per year, the missile is not considered significant. If the probability of occurrence is greater than 10^{-7} per year, the probability that it will impact a significant target is determined. If the product of these two probabilities is less than 10^{-7} per year, the missile is not considered significant. If the above product is greater than 10^{-7} per year, the probability of significant damage is determined. If the combined probability (product of all three) is less than 10^{-7} per year, the missile is not considered significant. If the combined probability is greater than 10^{-7} per year, missile protection of SSC important to safety should be provided by one or more of the six methods listed above.[34]

2. The reviewer determines if the separation analysis can be used to demonstrate adequate protection for SSC important to safety from missiles which may be generated inside containment. The reviewer should utilize the results of any high-energy line separation analysis review performed by EMEB for use in this evaluation. If an applicant uses spatial separation to justify adequate protection from missiles inside containment, then that evaluation should be consistent with that same applicant's use of spatial separation in response to high-energy line breaks. If damage can occur to only one division of safety-related systems, the requirement for separation of redundant equipment is met. If more than one division can be damaged by high-energy piping, barriers, shields, and enclosures will be utilized to protect SSC important to safety.[35]

For standard design certification reviews under 10 CFR Part 52, the procedures above should be followed, as modified by the procedures in SRP Section 14.3 (proposed), to verify that the design set forth in the standard safety analysis report, including inspections, tests, analysis, and acceptance criteria (ITAAC), site interface requirements and combined license action items, meet the acceptance criteria given in subsection II. SRP Section 14.3 (proposed) contains procedures for the review of certified design material (CDM) for the standard design, including the site parameters, interface criteria, and ITAAC.[36]

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided and that his evaluation supports conclusions of the following type, to be included in the staff's safety evaluation report:

The review of possible effects of internally generated missiles (inside containment) included structures, systems, and components (SSC)[37] whose failure could prevent safe shutdown of the plant or result in significant uncontrolled release of radioactivity. Based on the review of the applicant's design bases and criteria for ~~essential structures, systems, and components~~the SSC important to safety[38] necessary to maintain a safe plant shutdown, the staff concludes that the structures, systems, and components to be protected from internally generated missiles (inside containment) meet the requirements of General Design Criterion 4 with respect to protection of ~~safety-related SSC~~SSC important to safety[39] from internal missiles inside containment since the applicant:

1. Has used methods for identification of potential sources of internal missiles and for demonstrating the adequacy of the protection provided which have been reviewed by the staff in this or in previous applications and found acceptable; ~~and~~[40]

2. Has shown that ~~essential SSC~~ the functions of SSC important to safety[41] will be protected from internally generated missiles (inside containment) by locating the systems or components in individual missile-proof structures, providing adequate physical separation for redundant systems or components of the system,[42] or providing special localized protective shields or barriers.; and[43]

3. Has shown that controls are provided to ensure that all unsecured maintenance equipment inside containment, including equipment required for maintenance and equipment undergoing maintenance, will not generate a potential missile hazard.[44]

For design certification reviews, the findings will also summarize, to the extent that the review is not discussed in other safety evaluation report sections, the staff's evaluation of inspections, tests, analyses, and acceptance criteria (ITAAC), including design acceptance criteria (DAC), site interface requirements, and combined license action items that are relevant to this SRP section.[45]

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

This SRP section will be used by the staff when performing safety evaluations of license applications submitted by applicants pursuant to 10 CFR 50 or 10 CFR 52.[46] Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

The provisions of this SRP section apply to reviews of applications docketed six months or more after the date of issuance of this SRP section.[47]

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and ~~Missile~~Dynamic Effects[48] Design Bases."

Item numbers in the following table correspond to superscript numbers in the redline/strikeout copy of the draft SRP section.

Item	Source	Description
1.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB names and responsibilities for this SRP section.
2.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB names and responsibilities for this SRP section.
3.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB names and responsibilities for this SRP section.
4.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB names.
5.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB names.
6.	Editorial.	To be consistent with the remainder of the section the acronym SSC was used in place of structures, systems, and components.
7.	Editorial and resolution of PI-24288.	The phrase "or prevention of a significant uncontrolled release of radioactivity" was added to the Areas of Review discussion on the review of applicable SSC. Including this phrase ensures consistency between the discussion in the Areas of Review and the Evaluation Findings. In addition, this change is consistent with the documented reviews in section 3.5.1.2 of the ABWR FSER which includes a review of missile protection features for the SSC whose failure could prevent the safe shutdown of the facility or result in significant uncontrolled release of radioactivity (see PI-24288).
8.	Editorial and resolution of PI-24288.	The phrase "safety-related SSC" was replaced with the phrase "SSC important to safety" which is broader terminology consistent with the changes made to the Evaluation Findings and the reviews documented in section 3.5.1.2 of the ABWR FSER (see PI-24288).
9.	Editorial and resolution of PI-24288.	The phrase "or prevention of a significant uncontrolled release of radioactivity" was added to the Areas of Review discussion on the review of applicable SSC. Including this phrase ensures consistency between the discussion in the Areas of Review and the Evaluation Findings. In addition, this change is consistent with the documented reviews in section 3.5.1.2 of the ABWR FSER which includes a review of missile protection features for the SSC whose failure could prevent the safe shutdown of the facility or result in significant uncontrolled release of radioactivity (see PI-24288).

Item	Source	Description
10.	SRP-UDP format item.	Revised review interface section of Areas of Review to be consistent with SRP-UDP required format that uses a number/paragraph format to distinguish individual reviews and supporting reviews performed by other PRBs.
11.	Editorial.	Revised the introductory sentence for the review interface section to be consistent with the format used in the SRP-UDP. To allow for review interfaces to other branches, the sentence had to be revised to be more general, rather than referencing the Structural Engineering Branch only. To maintain consistency, the deleted phrase, "the results used to complete the overall ASB evaluation of the protection against internally generated missiles" was added to the last sentence of the two individual review interfaces.
12.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB names and responsibilities for SRP section 3.5.3.
13.	Editorial.	See discussion for item number 11 regarding the repositioning of this last sentence.
14.	**Integrated Impact # 788** and SRP-UDP format item.	An Area of Review (review interface) to SRP section 3.6.2 was added to be consistent with the review interfaces documented in section 3.5.1.2 of the ABWR FSER. This review interface addresses the spatial requirements associated with the dynamic effects of pipe breaks and their use in evaluation of adequate protection from internally generated missiles inside of containment.
15.	Editorial.	The last sentence of the Areas of Review was revised so it is consistent with the SRP-UDP format. Added the phrase, "For the areas of review identified above" added the word, "referenced" and made the sentence plural to reflect the fact that there is now more than one review interface.
16.	Editorial.	Use of the phrase "structures and essential systems and components" was replaced with the term "SSC important to safety." Use of the term "SSC important to safety" is consistent with GDC 4 and with the terminology used in the remainder of the section to identify those SSC that have a safety concern involving missile protection.
17.	Editorial.	Substituted the acronym SSC for Structures, Systems and Components as is consistent with the remainder of the section.

Item	Source	Description
18.	Editorial.	Use of the phrase "structures housing essential systems and to the systems" was replaced with the term "SSC important to safety." Use of the term "SSC important to safety" is consistent with GDC 4 and with the terminology used in the remainder of the section to identify those SSC that have a safety concern involving missile protection.
19.	Editorial.	Use of the phrase "essential structures, systems, and components" was replaced with the term "SSC important to safety." Use of the term "SSC important to safety" is consistent with GDC 4 and with the terminology used in the remainder of the section to identify those SSC that have a safety concern involving missile protection.
20.	Editorial.	Restating the phrase "for providing protection from internally generated missiles (inside containment)" adds no new information and is redundant.
21.	SRP-UDP format item, adding technical rationale.	Technical Rationale was developed and added for the Acceptance Criteria covering GDC 4. The SRP-UDP requires technical rationale be developed for the Acceptance Criteria.
22.	Editorial.	Substituted the acronym SSC for structures, systems, and components as is consistent with the remainder of the section.
23.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB abbreviation for Reactor Systems Branch.
24.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB names and abbreviations.
25.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB names and responsibilities for this SRP section.
26.	Editorial and resolution of PI-24288.	The phrase "and preventing significant uncontrolled release of radioactivity" was added to the Review Procedure discussion on the review of applicable SSC. Including this phrase ensures consistency between the discussion in the Review Procedures and the Evaluation Findings. In addition, this change is consistent with the documented reviews in section 3.5.1.2 of the ABWR FSER which includes a review of missile protection features for the SSC whose failure could prevent the safe shutdown of the facility or result in significant uncontrolled release of radioactivity (see PI-24288).
27.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB names and responsibilities for this SRP section.

Item	Source	Description
28.	Editorial.	Deleted the word "procedure" which is redundant for this usage.
29.	Editorial.	Substituted the acronym SSC for structures, systems, or components as is consistent with the remainder of the section.
30.	Editorial.	Use of the term "safety-related SSC" was replaced with broader term "SSC important to safety." Use of the term "SSC important to safety" is consistent with GDC 4 and with the terminology used in the remainder of the section to identify those SSC that have a safety concern involving missile protection.
31.	Editorial.	Substituted the acronym SSC for structures, systems, or components as is consistent with the remainder of the section.
32.	Editorial, adding a sentence consistent with and supporting existing Acceptance Criteria and resolution of PI-24290.	A sentence was added to the second to last paragraph of the Review Procedures to discuss the review performed to verify that the degree of protection is adequate. The six methods of protection are consistent with the NRC staff reviews documented in sections 3.5.1 and 3.5.1.2 of the ABWR FSER (see PI-24290) and are consistent with the existing Acceptance Criteria and Evaluation Findings.
33.	**Integrated Impact #535**	A review procedure was added to address controls provided for unsecured maintenance equipment inside containment, including equipment required for maintenance and equipment undergoing maintenance. The new review procedure is consistent with the staff guidance documented in section 3.5.1.2 of the ABWR FSER and addresses the issues discussed in NRC Notice 80-21.
34.	**Integrated Impact # 787**	A new paragraph was added to the review procedures to address the application of probability calculations used to evaluate the statistical significance of identified missiles. Because this change is based upon reviews documented in the ABWR FSER, the applicability of this new review procedure was limited to evolutionary plants only. The review procedure is consistent with the staff positions documented in section 3.5.1 of the ABWR FSER.
35.	**Integrated Impact # 788.**	A new review procedure for Evolutionary plants was added addressing use of the high-energy line spatial separation analysis in determining if adequate protection is demonstrated for SSC important to safety from missiles that may be generated inside of containment. The methods described in this Review Procedure are consistent with the approach documented in section 3.5.1.2 of the ABWR FSER.

Item	Source	Description
36.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard paragraph to address application of Review Procedures in design certification reviews.
37.	Editorial.	Added the acronym SSC for structures, systems, or components as is consistent with the remainder of the section.
38.	Editorial.	Use of the phrase "essential structures, systems, and components" was replaced with the term "SSC important to safety." Use of the term "SSC important to safety" is consistent with GDC 4 and with the terminology used in the remainder of the section to identify those SSC that have a safety concern involving missile protection.
39.	Editorial.	Use of the term "safety-related SSC" is not comprehensive and was therefore replaced with broader term "SSC important to safety." Use of the term "SSC important to safety" is consistent with GDC 4 and with the terminology used in the remainder of the section to identify those SSC that have a safety concern involving missile protection.
40.	Editorial.	deleted the "and" to make this series of items grammatically correct.
41.	Editorial.	Use of the term "safety-related SSC" is not comprehensive and was therefore replaced with broader term "SSC important to safety." Use of the term "SSC important to safety" is consistent with GDC 4 and with the terminology used in the remainder of the section to identify those SSC that have a safety concern involving missile protection.
42.	**Integrated Impact # 788.**	The phrase "providing adequate physical separation for redundant systems or components of the system" was added to the second evaluation finding. Adding this information on physical separation makes the evaluation findings consistent with the existing Acceptance Criteria and the added Review Procedures (see item 36). Adding a discussion on physical separation to the evaluation findings is also consistent with the evaluation findings as documented in section 3.5.1.2 of the ABWR FSER and the ABB-CE FSER.
43.	Editorial.	Added the "and" to make this series of items grammatically correct.

Item	Source	Description
44.	**Integrated Impact # 535.**	Added a third evaluation finding to address the controls implemented to ensure all unsecured maintenance equipment inside containment does not become a missile. The corresponding review procedure contains the details on the possible controls to be used. This evaluation finding is consistent with the staff reviews and guidance documented in section 3.5.1.2 of the ABWR FSER and the discussion contained in NRC Notice 80-21.
45.	10 CFR applicability issues.	A new Evaluation Finding was added to address design certification and combined license reviews. The design certification Evaluation Finding statement is consistent with the general statement utilized in the SRP-UDP.
46.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard sentence to address application of the SRP section to reviews of applications filed under 10 CFR Part 52, as well as Part 50.
47.	SRP-UDP Guidance	Added standard paragraph to indicate applicability of this section to reviews of future applications.
48.	Reference Verification.	The title of 10 CFR Part 50, Appendix A, GDC 4 was revised and now reads, "Environmental and Dynamic Effects Design Bases."

SRP Draft Section 3.5.1.2
Attachment B - Cross Reference of Integrated Impacts

Integrated Impact No.	Issue	SRP Subsections Affected
535	Incorporate appropriate review procedures and evaluation findings in regard to the controls provided to ensure that maintenance equipment, including equipment required for maintenance and equipment undergoing maintenance, will be prevented from becoming a missile hazardous to SSC important to safety.	Subsection III: Added a review procedure paragraph to address the review of the methods used to control potential maintenance derived missiles. Subsection IV: Added a third evaluation finding to discuss the findings in regard to this issue.
787	Incorporate appropriate Review Procedures to address the use of probabilistic criteria in evaluating the need to provide missile protection.	Subsection III: Added a Review Procedure (fifth paragraph item number 1).
788	Incorporate appropriate Review Procedures to address the use of the high-energy line separation analysis to determine adequate spatial separation for providing protection from missiles generated inside containment.	Subsection I: Added a new Review Interface (item 2) to the Areas of Review. Subsection III: Added a Review Procedure (fifth paragraph item number 2). Subsection IV: Added a phrase to item number 2 of the Evaluation Findings.